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Recently, search stopping behavior has gained attention from researchers. The purpose of the present research study was to investigate if users' level of domain knowledge influenced when they chose to end a search for information. The topic of stopping behavior was investigated using a convenience sample of 15 third-and fourth-year undergraduate students at a large university. This study investigated how users' level of domain knowledge influenced their decisions to stop information searches. Subjects were asked to complete four search task in which their completion time was measured. Subjects also completed questionnaires about their experiences and participated in an exit interview. The results of the study indicated that there was not an association between knowledge level and stopping behavior. However, the results of the study indicated there was a correlation between levels of domain knowledge and levels of interest in domains. There was also a strong correlation between the subjects' satisfaction with the search process and the retrieved results. Lastly, there was a negative correlation between the subjects' level of domain knowledge and their task times.

Headings:

Online searching
Information retrieval
Search satisfaction

TO WHAT EXTENT DOES DOMAIN KNOWLEDGE INFLUENCE SEARCH STOPPING BEHAVIOR?

by
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Table of Contents

Introduction

According to Rainie (2005), director of the Pew Internet and American Life Project, about 60 million American Internet users have used a search engine to search for information. They estimate that in 2004, there were approximately 38 million Internet users. In only one year, by 2005, that number rose to 59 million users (Google is the first choice and then Yahoo is the second choice of search engines in use) (Rainie, 2005). While this data does not address search behavior, the data suggests that the number of Internet users increases each year; therefore, search stopping behavior may be an important aspect of Internet, Web-based, and online library search behavior. Brown et al. (2007) define cognitive stopping rules as "A heuristic people invoke to make judgments about sufficiency" (Brown et al, 2007, pg. 90). Search stopping behaviors are the cumulative set of actions or reactions that people experience to particular circumstances that people using cognitive stopping rules as part of the decision-making process to end searches for information

This study investigates how different criteria (e.g. level of domain knowledge) influence search stopping behaviors and the reasons people stop information searches in the context of the Internet and Web-based services such as those found in libraries, digital libraries, and search databases.

Rainie (2008) finds that people search for information about the problems of daily living (e.g. education, health, and taxes); these are not ordinary general-interest types of searches (e.g. location, phone numbers, and restaurant locations). Rainie (2008) suggests

people have problems searching for topical information about legal action, military benefits, and education, to name just a few. Rainie (2008) also states that 169 million adults conduct these more problematic types of searches each year. These are areas of information searches that libraries and librarians increasing are asked to deliver; therefore, understanding the unique criteria that affects search stopping behavior in web-based and library environments is essential to improving the quality of searches for these 169 million adults (Rainie, 2008). Search stopping behavior is a small but important part of the larger process of search behavior that is required to understand the criteria users employ to end searches.

Researchers (Brown et al., 2002, 2007; Zach 2005; Berryman, 2008; Toms & Freund, 2009; Prabha et al, 2007) have identified stopping rules people employ to end searches for information in an online environment, such as online libraries or the Web. Users decide during online information searches which documents to review and save, when to reformulate queries, and when to end searches for information. Users employ cognitive stopping rules in the decision-making process as they evaluate and re-evaluate information. While the process of search behavior has been extensively researched, the process of ending a search or stopping behavior has produced limited research results.

Many researchers, such as Brown (2002, 2007), Zach (2005), and Prabha (2007), and Marchionini (1995) have investigated to varying degrees those influences on the decision-making processes users employ throughout the search process. These other influences include the following:

- Domain knowledge (familiarity with the topic) (Marchionini,1995)
- Task knowledge (familiarity with the task) (Marchionini, 1995)

- Complexity of the search task (Brown, 2004, 2007)
- Search experience of the user (Brown, 2004, 2007)
- Satisfaction with the search results (Prabha, 2007)
- Disgust with the search results (Prabha, 2007)

However, one criterion that lacks empirical investigation is the level of domain knowledge as Marchionini (1995) discusses who defined domain knowledge as the level of expertise a person possesses about a specific topic (e.g. medicine, sociology). The goal of this research study then is to investigate how users' levels of domain knowledge influences their decisions to stop a search for information. This lack of empirical evidence provides a key motivating factor for this study.

A study about how domain knowledge influences search stopping behaviors may help developers of online information systems understand how users behave in information search settings which might enable them to become more attuned to users' personal variables and thinking processes. This research may be valuable to those designing online library and Web-based applications in which their audiences typically have a wide range of domain knowledge, experience levels, and task knowledge based on age and education alone. This knowledge might also enable developers to be more creative in the design of more useful search interfaces that address varying kinds of search tasks, domain knowledge, results organization, search algorithms, databases structures, and the creation of new conventions. This may also help librarians better understand information use by library patrons who search for information.

Literature Review

Researchers listed throughout this literature review approach the study of search stopping behavior from various perspectives (e.g. triggers and cognitive stopping rules). Some researchers question whether a predictive nature to stopping behavior exists. A discussion of users' perspectives about satisfactory information includes cost-benefit analyses, role theory, and evaluations about what is *good enough* information. The following is a brief discussion of these topics as they relate to current information about search stopping behavior.

What triggers stopping behavior?

Researchers (Brown et al., 2004, 2007; Toms, 2009; Zach, 2005) investigate reasons that trigger cognitive stopping rules a user may employ to end an information search. Brown et al. (2007) define cognitive stopping rules as "A heuristic people invoke to make judgments about sufficiency" (Brown et al, 2007, pg. 90). Reasons that motivate a user to end an information search are usually cognitive, motivational, or affective. Our discussion concerns itself with cognitive stopping rules. Other reasons, such as motivational reasons, in which there is an external motivating source, such as a deadline; and affective reasons, such as emotions, all contribute to the desire to end an information search (Brown et al., 2007). However, to limit the scope and size of this research study, motivation and affective reasons are not discussed here.

Is stopping behavior predictive?

Researchers such as Toms et al. (2009) and Brown et al. (2004, 2007) try to determine whether there is a predictive nature to stopping behavior that is made evident

through empirical research. Brown et al. (2004, 2007) investigate the relationship between the complexity of the search task and the search experience of the user, and how these factors lend a predictive nature to stopping behavior. Brown et al. (2004, 2007) propose five cognitive stopping rules that users may tacitly employ during an online information search. Users employ cognitive rules based on how they process information using their own mental models (cognitive thought processes) about the search processes For example, Brown et al. (2004 2007) identify task complexity and search experience as two factors that might predict which cognitive stopping rules users apply to end an information search. The goal is that this information may assist web designers to design interfaces that support varying levels of complexity of search tasks along with varying levels of search experience (Brown et al., 2004, 2007) among users.

Other researchers, who also demonstrate interest in whether stopping behavior may have a predictive nature, include Toms and Freund (2009) who investigate whether users unknowingly leave behind behavioral cues in user-transaction logs. The authors state that three behaviors may predict that a user will stop a search: These are *view a page, view a second page, and follow a link on a page* (Toms & Freund, 2009). While these behaviors are part of the search process, the authors argue that these three behaviors may represent the users' moves toward stopping information searches (Toms & Freund, 2009). However, one can argue that any move or any click is one step in a cumulative series of steps users initiate to end a search.

Prabha et al. (2007) describes other rules people employ for stopping information searches. These rules are the satiation rule, the disgust rule, and the combination rule. The satiation rule states that users end a search after they are satiated by finding relevant

information. The disgust rule states that users stop a search after they have achieved a threshold of disgust from reviewing too many non-relevant or repetitive items. The combination rule states that users stop information searches after a threshold of a combination of both the satiation and disgust rules are achieved (Kraft & Lee, 1979; Prabha et al., 2007).

What is "good enough" information?

This discussion of unknown or known, spoken or tacit criteria that comprises cognitive stopping behavior leads researchers (Zach, 2005; Prabha et al, 2007; Brown et al, 2004, 2007, Berryman, 2008) to attempt to define exactly what is *good enough* information. What is the threshold at which users are satisfied with the amount and quality of information they collect and thus end information searches? This issue is addressed in empirical studies by Prabha (2007), Berryman (2005), and Zach (2005), which will be discussed below. However, a discussion of what is good enough information must begin with a discussion of the concept of satisficing by Simon (1955).

One researcher often cited is Simon (1955) who theorizes that people *satisfice* after they determine the results they achieve are *good enough*. This behavior may occur when individuals, for unknown reasons, lack access to all of the available options. Prabha (2007) argues that these individuals are unable to compare the cost necessary to expend additional efforts to continue the search for more information and thus, determine if enough benefits may be achieved to make the effort (cost) worthwhile. However, Simon's focus is on the notion that satisficing is an alternative to rational decision making when searching. Simon emphasizes the notion that people determine if an alternative approach, such as satisficing, is a good enough approach to meet their search

goals and satisfy their information needs. This behavior is a cognitive process in which users alternatively judge back and forth the value of more effort (cost) versus enough information (benefit). Saad and Russo (1996) state that it is at this point in the cost-benefit analyses that users must commit to the choices of information they acquire. Thus stopping behavior indicates a level of commitment to information users' deem acceptable as good enough. This commitment occurs before users actually end their searches and indicates the complexity of the cognitive process, the iterative nature of the decision process, and the variables users unknowingly and tacitly address when they make cognitive decision about information (Saad & Russo, 1996).

Saad and Russo (1996) also discover evidence to support the notion that people establish thresholds of information that once reached, allows them to make decisions. The authors propose that users address the mental analyses of costs and benefits as part of the process that leads to stopping. However, if the under- or over-accumulation of information does not lead to acceptable cost-benefit ratios, then users adapt their behavior by varying their thresholds. This behavior results in adaptive thresholds (Saad & Russo, 1996).

Brown et al. (2002) corroborate the cost-benefit analysis Saad and Russo (1996) offer. Brown, et al. (2002) describe stopping rules in the context of the costs and benefits associated with those users who under- or over-acquire information. Those users who under-acquire information do so at the cost of collecting insufficient information to make informed decisions. Those who over-acquire information do so at additional costs of time and energy without additional benefits (Brown et al., 2002).

Other ways to think about stopping behavior is in the context of Role theory. Prabha et al. (2007) use Role theory to explain the similarities and differences in the stopping behavior of students and faculty members. They discovered that the social role of the subjects affects the stopping behaviors of students and faculty members. Students have a specific objective to complete a class assignment. However, faculty members indicate they have more open-ended needs, such as feedback from colleagues, reviewers, and others (Prabha, 2007).

This study by Prabha et al. (2007) lends support to the notion that context also influences decision making. Through focus group interviews, they determine that quantitative data (e.g. number of pages, number of citations, and numeric data) are sufficient data for students to decide to end searches for information. Qualitative reasons are information accuracy, repetition, and quality of information. The perspective from the faculty members is quite different than that of the students; faculty members indicate that the time available was the most important factor they use to determine when to stop a search. Qualitative reasons include trustworthiness of source, representative samples, cutting-edge research, repetition, exhausted information available, and colleagues' feedback (Prabha et al., 2007).

Berryman (2008) also raises the issue that good enough information is a matter of context. This means that the information users collect is good enough in one environmental context but may not be good enough information in another context. For example, information users collect for a one-page summary report may not be good enough for a ten-page feasibility study for their managers.

Both studies by Zach (2005) and Berryman (2008) provide evidence about the influences people experience in two specific work domains. Zach (2005) conducts interviews with 12 arts administrators to understand the decision-making processes they use to end searches for information. Zach discovers that administrators have a tendency to rely on their own personal experience as part of the data they use to satisfy an information need. Zach also found that administrators often *satisfice*. Administrators know there is more information available, but it is unnecessary or the benefits of the additional data are not worth the effort (cost) they must extend. Zach's study demonstrates that decision-making processes about when to end information searches has many contexts and is an iterative process that occurs over varying periods of time, such as minutes, hours, or days (Zach, 2005).

Similarly, Berryman (2008) conducts interviews of public sector workers to identify their influences to stop searches. Berryman found the major influences on users exist in the form of pressure from colleagues and the organizational culture, as well as inherent properties associated with the work task. These results stress the complexity of context and social pressures and how these variables influence the criteria people use to determine to stop searches (Berryman, 2008).

What are the summaries drawn from this literature review?

This study continues along the same lines as other researchers by using a convenience sample of university students as subjects in a laboratory setting. From these research studies, the following ideas are summarized:

- Users invariably make cost-benefit analyses while they search for information.
- Users invariably make cost-benefit analyses while they evaluate information.

- Information search requires people to adapt their thresholds to determine what constitutes good enough information.
- The roles of users affect their decision to end a search.

The discussion of the studies informs this research paper by providing context for the study. Research has been conducted to examine the relationship between users' level of domain knowledge and their search tactics (Wildemuth et al., 2004); however, little empirical research has been conducted on how the levels of domain knowledge influence users' decisions to end information searches. Thus, this research seeks to address the following question: Does users' domain knowledge influence their search stopping behavior?

Method

Study Population

The population for this research study was defined as adult third- and fourth-year undergraduate students who were enrolled at a large university (approximately 29,000 students). This population was further identified as possessing varying levels of domain knowledge based on their participation in university studies and based on meeting university requirements for first- and second-year academic coursework to advance to third- and fourth-year status.

Once the IRB was approved, subjects were recruited through an email to the third- and fourth-year student body at the university. Inducements of $10 US dollars per subject were offered for participation in this study. The first 15 students who responded and met the inclusion requirements (e.g. third- and fourth-year student) were enrolled.

One thing to note is that as subjects arrived, some of them were unaware if they were second- or third-year students or the number of credits they had completed prior to the current term of the study. To address this, the researcher asked the subjects for the number of credits they had completed to verify that they were indeed third- or fourth-year students and that they had completed greater than 60 credits. This allowed the researcher to re-categorize students who thought they were second-year based on credits to third-year status.

Once subjects arrived at the study location, they were given a fact sheet. After subjects read this form, the subjects' verbal "I accept" was interpreted by the researcher as informed consent. A signature was not collected and thus did not tie the subject to any other information. A signature was only collected to certify that they received the $10 inducement to participate.

Procedure

A controlled laboratory study was used as the principle method. Questionnaires, transaction logs, and interviews were used as the primary data collection instruments. The experiment took subjects approximately 30 minutes to complete.

Subjects were scheduled based on the order in which they responded to the recruitment email. Subjects were rescheduled if their own schedule changed and they requested a change that could be accommodated. If subjects did not arrive for the study even after receiving a reminder email, the next subject on the list was selected and scheduled.

Once subjects arrived at the lab, they were asked to complete the following questionnaires and search tasks, as listed below.

1. Demographics questionnaire included general demographic information about the subject, such as age and sex.
2. Search experience questionnaire included questions about how many hours per day subjects spent on certain kinds of search tasks.
3. Computer/Internet/Web 2.0 questionnaire included questions about subjects' knowledge about computers and features associated with the Internet.
4. Search self-efficacy questionnaire included questions about subjects' beliefs about their information search abilities.

Subjects were then assigned four search tasks. Before they began each of their search tasks, they answered two questions about their domain knowledge and interest. Next, subjects completed the search tasks. Once subjects completed the first search task, they completed two more questionnaires about their search satisfaction and reasons for stopping. In addition, subjects' search task times were recorded using a client-side transaction logger. This logger recorded keystrokes and mouse clicks, as well as time. The sequence of events was as follows:

1. Domain knowledge question (pre-search task): A question about subjects' knowledge about certain domains.
2. Domain interest question (pre-search task): A question about subjects' interest in certain domains.
3. One search task: exploratory search to answer a multi-answer question.
4. Search satisfaction (post-search task): Questions about subjects' satisfaction with the search experience.

5. Reason for stopping (post-search task): Questions about why subjects ended a search. These steps were repeated with different search tasks (English Literature, Geometry, Psychology, and Botany) for a total of four search tasks. Search tasks were counterbalanced among the subjects.

Lastly, an exit interview was conducted and audio-recorded. The results of the audio-recording were transcribed. The interview included five pre-search and four post-search result questions.

Once the study data was collected, the data was analyzed and re-analyzed. The transaction logs were examined for tasks start and end times. The times were entered into SPSS along with all the other data from the study. Descriptive statistics were calculated on the demographic data. Descriptive and inferential statistics were calculated on the search-related data. Lastly, discussions about the data and observations about the results were written.

Questionnaires

Search Experience

Subject search experience was measured with three questions (Table 1). The first question measured subjects' search experience with locating specific information such as the address, the map, or the phone number of a restaurant. The second question measured subjects' search experience with searching for general information such as that found in a news story, blogs, or electronic publications. The third and last question measured subject's search experience with exploring information to learn something new. Subjects were asked to estimate the number of hours per week, in five-hour increments, they spent performing these types of searches.

Table 1. Search Experience Questionnaire

	1-5	6-10	11-15	16-20	21-25	26-30	31-35
How many hours per week do you spend searching the web to answer a specific question? (ex: find a restaurant location or movie time)							
How many hours per week do you search for general information? (ex: news)							
How many hours per week do you spend on exploratory search tasks? (ex: learning about a new topic, curiosity, problem solving)							

Computer/Internet/Web 2.0

Subject computer experience measured eight features associated with Internet and web search (Table 2). The first four features were general use such as email, video, news groups, and web search. The last four features were blogging, RSS feeds, collaboration sites (Wikipedia), and social networking sites (Facebook). Subjects were asked to assess their experience with each feature on a ten-point scale from 1 (No Experience) to 7 (Expert Experience).

Table 2. Computer Experience Questionnaire

	No Experience						Expert Experience
	1	2	3	4	5	6	7
Email							
Web search							
news groups							
videos							
Blogging							
Wikipedia							
RSS feeds							
Social networks (ex: Facebook, twitter)							

Search Self-Efficacy

Subjects' search self-efficacy was measured with a questionnaire that was modified from Debowshi (2001). This questionnaire measured subjects' beliefs about their search abilities. It contained fourteen questions (Table 3). Subjects were asked to assess themselves in response to each statement on a ten-point scale from 1 (Totally Unconfident) to 10 (Totally Confident).

Table 3. Search Self-Efficacy Questionnaire

Level of Confidence									
Totally Unconfident				Reasonably Confident				Totally Confident	
1	2	3	4	5	6	7	8	9	10

I can:	Confidence (1 – 10)
Identify the major requirements of the search from the initial statement of the topic.	
Correctly develop search queries to reflect my requirements.	
Use special syntax in advanced searching (e.g., AND, OR, NOT).	
Evaluate the resulting list to monitor the success of my approach.	
Develop a search query which will retrieve a large number of appropriate articles.	
Find an adequate number of articles.	
Find articles similar in quality to those obtained by a professional searcher.	
Devise a query which will result in a very small percentage of irrelevant items on my list.	
Efficiently structure my time to complete the task.	
Develop a focused search query that will retrieve a small number of appropriate articles.	
Distinguish between relevant and irrelevant articles.	
Complete the search competently and effectively.	
Complete the individual steps of the search with little difficulty.	
Structure my time effectively so that I will finish the search in the allocated time.	

Domain Knowledge

Subjects' level of domain knowledge was measured with a single question (Table 4) that asked them to assess their domain knowledge of the topic based on a five-point scale from 1 (No Knowledge) to 5 (Expert Knowledge).

Table 4. Domain Knowledge Question

	No Knowledge				Expert Knowledge
	1	2	3	4	5
Geometry					

Domain Interest

Subject's interest level in a domain was measured with a single question (Table 5) that asked subjects to assess their interest in the domain based on a five-point scale from 1 (No Interest) to 5 (Very Interested).

Table 5. Domain Interest Questionnaire

	No Interest				Very Interested
	1	2	3	4	5
Geometry					

Search Tasks

Subjects were asked to conduct search tasks in four domain areas: Botany, Geometry, English Literature, and Psychology. The domain knowledge areas used in this research study were selected based on the coursework student should have completed prior to their third-year of college at this particular university. Thus, the assumption was that all subjects were familiar with these domains based on courses selected from the first- and second-year curriculum but that some differences in knowledge and interest existed.

Each of the four search tasks were developed for this study. Each task contained instructions for the subjects to locate five pieces of information about a topic within a domain, with examples of five possible questions included about which they could find information. The tasks were placed in the context of a larger conceptual framework within which someone might normally search for information. The questions ranged from facts, such as year of birth, to open-ended questions, such as an author's

contribution to modern life. Tasks were counter-balanced among the subjects to control for any learning effects that might occur as subjects completed and proceeded from task to task. The tasks are listed below:

- *Search task 1:* You are writing a short tourism piece for the state of North Carolina. You have been requested to write about the Magnolia Grandiflora. Write down five pieces of information about the Magnolia. A few suggestions may be what is the Magnolia? What is the genus, where is it found, what are the flowers like? What types of products are made from the Magnolia?
- *Search task 2:* You are creating a new dictionary about famous people. You have been asked to collect some information about your favorite mathematician. You choose Pythagoras. Write down five pieces of information about Pythagoras. A few suggestions may be who was he, where was he born, why is he important, what did he contribute to the world? How did his contribution affect modern life? Who were his greatest influences?
- *Search task 3:* You have been tasked with collecting information about a book you have not heard of: *The Sand Pebbles*. Write down five pieces of information about this book and the author. A few suggestions may be who is the author, when was he born, and why did he write the book? What were his influences and who were his contemporary writers? What experiences did he draw on to write the book? What is the significance of this book?
- *Search task 4:* Today, the field of Psychology has many branches. You are investigating famous psychologists, such as Carl Jung. Write down five pieces of information about Carl Jung. A few suggestions may be what were a few of the

psychological concepts credited to Jung? What was the psychometric instrument created that was credited to the theories of Jung? Who were his contemporaries and what other psychologists did Jung study with?

Search Satisfaction

Subjects' satisfaction with the results of the search tasks was measured with two questions (Table 6). The first question measured satisfaction with the search process itself. The second question measured satisfaction with the search results obtained from the search process. Subjects were asked to assess their satisfaction based on a five-point scale from 1 (Very Dissatisfied) to 5 (Very Satisfied).

Table 6. Search Satisfaction Questionnaire

	Very Dissatisfied				Very Satisfied
	1	2	3	4	5
How satisfied or dissatisfied are you with the search process?					
How satisfied or dissatisfied are you with the search results obtained?					

Reasons for Ending Searches

Subjects' reasons for ending searches were measured with five statements (Table 7): (1) the first statement measured the subject's perception of using a predetermined mental list of items in which all of the items on this predetermined list were checked, much like a list of items was checked off of a to-do-list; (2) The second statement measured the subjects' perception of the degree to which the documents listed were changing by the addition and removal of documents as the subject searched; (3) The third statement measured the subjects' perception of whether they were learning anything new by implying they were no longer finding any new documents that were worth reviewing; (4) The fourth statement measured the subjects' perception that the information they found was good enough; (5) The fifth question measured the subjects'

perception that the information provided an answer to a single-answer question. Subjects were asked to rate each statement on a five-point scale from 1 (None) to 5 (Very Much). These items were derived from cognitive stopping rules identified in previous work by Brown et al., 2004, 2007.

Table 7. Reasons for Stopping a Search Questionnaire

	None				Very Much
I ended my search for documents because	**1**	**2**	**3**	**4**	**5**
I satisfied all the items I needed from my mental list of items.					
I retrieved a set of documents that were no longer changing.					
I determined I was no longer learning anything new.					
I skimmed the documents and determined the information I had was good enough.					
I found the answer to a question that required a single answer.					

Exit Interviews

An open-ended interview was conducted to draw forth information that might not be captured in the self-assessment questionnaires or transaction logs (Table 8). Interview information was developed under influence from interviews conducted by Zach (2005), Berryman (2008), and Rieh (2004). The interviews were divided into two sections. The first section contained five questions that were asked to assess how subjects made choices about which links they selected from the search results displayed by the search engine.

Table 8. Pre-search results interview questions

Pre-results interview questions
1. How did you determine what information to search for to complete the task?
2. Where did you look for information?
3. What criteria did you use to evaluate the search results?
4. Did you know the answer to a question without searching for the answer?
5. If you were familiar with the topic, where/how did you search for information?

The second set of four questions was asked to examine how subjects selected an answer from within the documents they retrieved. These questions are displayed in Table 9. The interviews were audio-recorded using the Sound Recorder in the Accessories folder on Windows Vista and then transcribed into a Word document.

Table 9. Post results interview questions

Post-results interview questions
1. What criteria did you use to decide the answer was the one you wanted?
2. Were you satisfied with the search results?
3. How did you determine the answer was good enough?
4. What did you learn about the topic?

Transaction Logs

The primary goal for using a transaction log was to collect the time when subjects initiated a search, indicated by the search-task start time, and completed a search indicated by the search-task end times. This method allowed the researcher to review the subjects' search behavior by examining recorded search terms, clicking behaviors, search paths, and lastly, the URLs visited for each domain.

This method utilized a client-side collection tool, specifically, Jansen's (2006) *Wrapper*, because it was easy to use, it was accessible, and it was unobtrusive throughout the research study. The transaction log software was created and designed by Jansen (2006) specifically for researchers. This open-source software works on a Windows 9X/2K/XP platform. In this study, Wrapper was used in a Windows Vista environment in an emulation mode.

Search tasks were timed using Wrapper transaction log (Jansen, 2006). Subjects entered "task x" (x being task 1, 2, 3, or 4) before they read the search task. Task time was recorded as the total time subjects read the task and conducted the search. This time

was measured based on the starting point, task x, and then the last search entry made prior to starting the next task, task y. At the end of task four, subjects entered “stop now” in the query box. The last search entered before “stop now” was considered the end time of the fourth search task.

Results

To reiterate, the goal of this research study was to investigate whether subjects’ levels of domain knowledge influenced their decisions to end searches for information. The research question asked if there was an association between the users’ level of domain knowledge and their stopping behavior; specifically, to what extent does the users’ level of domain knowledge influence when subjects chose to end a search for information.

Subjects

A total of 15 people (10 females and 5 males) completed this study. One student was a second-year, five were third-year, and nine were fourth-year students. Their ages ranged from 19 to 22 with an average age of 20.33 years. All subjects had completed 60 to 120 credits prior to participating in the study. Additionally, the subjects identified a wide range of college majors as shown in Table 10.

Table 10. Current college majors indicated by subjects. (*) indicates these major were associated with double-majors; thus, the total subject population displayed in the figure is greater than 15.

College Majors	Counts
Asian studies*	1
Biology*	1
Chemistry	1
Communications	1
Computer Science	1
English/Journalism	2
History*	3
Languages*	3
Philosophy*	2
Political Science*	1
Psychology*	2
Sociology	1

While the goal was to recruit third- and fourth-year students, all students who identified themselves as second-year had completed greater than sixty credits, which qualified them as third-year status; thus they were retained and re-categorized as third-year students for the study.

Subjects' Self-Assessment of Search Experience for Three Types of Searches

Subjects were asked to estimate how many hours per week, in five-hour increments, they performed the following three different types of searches:

- searches to answer specific questions (e.g. restaurant location, movie time);
- searches for general information (e.g. news); and
- exploratory searches for new information (e.g. learning about a new topic).

Subjects' estimated that the time they spent conducting these three types of search activities were similar. The means and standard deviations (SDs) are shown in Table 11. Subjects' estimates ranged from 1 to 4 with means of 1.53, 1.67, and 1.80.

Table 11. Means and SDs of hours/week subject spent on three types of searches

	Min.*	Max.*	Mean	SD
specific question searches	1	4	1.53	.834
general information searches	1	4	1.67	1.047
Exploratory type searches	1	4	1.80	1.014
***** 1=1-5 hrs/week; 2=6-10 hrs/week; 3=11-16 hrs/week; 4=16-20 hrs/week N=15				

The mean data values translate to an approximate range of 1-5 to 16-20 hours per week in which subjects estimated they conduct these three types of searches. However, the mean data suggests that subjects spend more time performing exploratory searches than performing searches to answer general or specific questions. Since exploratory tasks often take more time due to the very nature of the task than specific question or general information searches, it is expected that the mean for exploratory search is greater.

Subjects' Self-Assessment of Computer Experience

Subjects were asked to assess their computer experience for general uses such as email, video, news groups, and web search and for their experience with social web features such as blogging, RSS feeds, collaboration sites (e.g. Wikipedia), and social networking sites (e.g. Facebook). Subjects rated their level of experience with RSS feeds the lowest, 2.07, which was next to no experience (1) in the Table 12. Subjects rated their experience with social networks the highest, 5.87, which was next to expert experience (7) in Table 12.

Table 12. Means and SDs for subjects' self-assessment of computer experience

	Minimum*	Maximum*	Mean	SD
Email	4	7	5.73	.884
Web search	3	7	5.40	1.183
Newsgroup	2	6	3.67	1.397
Videos	2	6	4.53	1.552
Blogging	1	6	3.80	1.781
Wikipedia	4	7	5.67	.900
RSS feeds	1	5	2.07	1.223
Social networks	4	7	5.87	1.060
N=15				

Interestingly, subjects rated their web search experience as 5.4. Ratings of 5 and 6 were considered greater than average (4) experience but less than expert experience (7). Web search was the activity in this study in which subjects were requested to engage.

Subjects Self-Assessment of Search Self-Efficacy

Subjects were asked to assess their own attitudes about how confident they felt conducting searches for information on the Web. Their responses ranged from two to ten with a range of means from 5.93 to 8.00 for each of the different items (Table 13). An assessment of 5 and 6 was identified as reasonably confident and an assessment of 10 was identified as totally confident. An assessment of 1 was identified as totally unconfident.

The average mean for all 15 responses to all 14 questions was 7.27 with an SD of 1.65. This meant that on the whole, subjects assessed themselves to be more than reasonably confident to near expert in their abilities to perform different search tasks on the Internet.

Table 13. Means and SDs for subjects' self-assessment of confidence in conducting searches

	Minimum*	Maximum*	Mean	SD
Q1	6	9	7.93	1.033
Q2	4	10	7.93	1.486
Q3	3	9	6.33	1.988
Q4	5	10	7.73	1.668
Q5	4	10	7.73	1.486
Q6	6	10	8.00	1.254
Q7	3	9	6.07	2.086
Q8	2	9	5.93	2.219
Q9	4	9	6.93	1.624
Q10	3	10	6.53	2.200
Q11	5	10	7.93	1.223
Q12	5	10	7.73	1.668
Q13	6	10	7.80	1.521
Q14	4	10	7.20	1.656
Total Mean/ 14=Mean			7.27	1.65
*1=Totally Unconfident; 5/ 6= Reasonably Confident; 10=Totally Confident N=15				

Subject's Self-Assessment of Level of Domain Knowledge

Subjects were asked to assess their levels of domain knowledge about the four search domains: Botany, Geometry, Literature, and Psychology (Table 14). Seven subjects or 12% of the subjects indicated they possessed no knowledge about Botany and Geometry. A total of 28% of subjects indicated low levels of knowledge about all four search domains. A high percentage of subjects, 38% indicated they had an average level of knowledge about the search domains. Lastly, 20% indicated high knowledge levels about the search domains. Only one subject expressed expert-level knowledge in one of the domains, which in this case was Psychology.

Table 14. Counts for subjects' self-assessments of level of knowledge about search domains

Search Domains	Knowledge					
	No Knowledge 1	2	Average 3	4	Expert Knowledge 5	Total
Botany	6	8	1	0	0	15
Geometry	1	2	7	5	0	15
Literature	0	3	8	4	0	15
Psychology	0	4	7	3	1	15
Total	7	17	23	12	1	60
%	12%	28%	38%	20%	2%	100%

From the contingency table above, a Chi-square was calculated to examine whether an association presented between the distributions for search domains and subjects assessed level of knowledge about the search domains (Table 15). The chi-square indicated an association between search domain categories and knowledge levels expressed by the subjects (Chi-square=32.040, *df*=12, *p*=.001). The strength of the association was measured with Cramer's V=0.422, which indicated moderate strength in association. Cramer's V was measured on a scale of 0 to 1 with 0 meaning no association to 1 meaning perfect association.

Table 15. Chi-square and Fisher's Exact Test calculations for association between knowledge and domains

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	32.040	12	.001	
Fisher's Exact Test	28.543			.001
N of Valid Cases	60			

Additionally, because the numbers within many of the cells of the table were less than five, precision was problematic with the chi-square calculation. To evaluate for association more precisely, a Fishers' Exact Test was calculated and indicated there was an association between domains and subjects' level of knowledge that is unlikely

attributed to chance (Fishers=28.543, *p*=.001). These tests showed that the distribution of knowledge across the various domains was significantly different from one another.

Subjects' Self-Assessment of Level of Domain Interest

Table 16 shows a comparison of subjects' assessment about their level of interest in the four domain areas. Many subjects, 45%, indicated they possessed no or low interest (1, 2) in Botany and Geometry. Only one subject indicated no interest (1) in Literature. Zero subjects indicated no or low interest in Psychology. The average interest in the four domains was 27%. Lastly, 28% indicated they were interested or very interested in the four search domains; however, only one was very interested in Botany and two in Geometry.

Table 16. Counts for subjects self-assessments of interest in search domains

Search Domains	Interest					
	No Interest 1	2	3	4	Very Interested 5	Total
Botany	4	5	5	0	1	15
Geometry	6	6	1	2	0	15
Literature	1	5	4	1	4	15
Psychology	0	0	6	5	4	15
Total	11	16	16	8	9	60
%	18%	27%	27%	13%	15%	100%

From the contingency table above, a Chi-square was calculated to examine whether there was an association between the distributions for search domains and subjects' expressed interest in the search domains (Table 17). The chi-square indicated there was an association between search domain categories and subjects' interest levels in those domains (Chi-square=29.939, *df*=12, *p*=.003). The strength of the association was moderate as measured by Cramer's V=.408. A Fishers' Exact Test indicated there was an

association between interest and the domains that is unlikely attributed to chance (Fishers=29.893, *p*=.001).

Table 17. Chi-square and Fisher's Exact Test for association between interest and search domains

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	29.939a	12	.003	
Fisher's Exact Test	29.893			.001
N of Valid Cases	60			

Subjects' Self-Assessment of Satisfaction with the Search Processes/Results

After each search task, subjects were asked to assess their satisfaction with the search process and with the search results obtained from the search process as they completed the search task. The subjects' rated their satisfaction on a scale of 1 to 5; the subjects' average rating was 3.87 for both the search processes and the search results (Table 18).

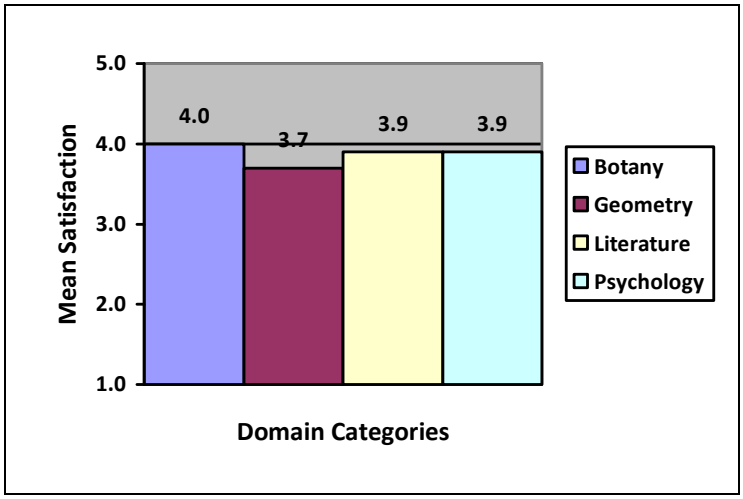
Table 18. Means and SDs for self-assessment of satisfaction with search processes and search results

	N	Min.	Max.	Mean	SD
Satisfied with process	60	2	5	3.87	.947
Satisfied with results	60	2	5	3.87	1.081

Subjects' Self-Assessment of Satisfaction with the Search Processes

Table 19 displays the counts for the search domains and the subjects' self-assessment ratings of their satisfaction with the domains for the search tasks. Zero subjects reported being very dissatisfied (1) with the search process. Only 8% of subjects indicated they were dissatisfied with the search process. For the most part, 65% of the subjects were satisfied and very satisfied with the search process. Many subjects, 27% were neutral in their satisfaction about the search process.

Figure 1. Mean search satisfaction by domain category



Satisfaction levels were easily observable when one compared the mean satisfaction ratings across the four different search domains as shown in Figure 1. Clearly, Subjects indicated they were least satisfied with the search task in Geometry.

Table 19. Counts for subjects' self-assessment of satisfaction with search processes

Search Domains	Satisfaction with Search Process					
	Very Dissatisfied 1	2	3	4	Very Satisfied 5	Total
Botany	0	0	6	3	6	15
Geometry	0	2	3	7	3	15
Literature	0	2	3	5	5	15
Psychology	0	1	4	6	4	15
Total	0	5	16	21	18	15
%	0	8%	27%	35%	30%	100%

The chi-square was calculated to examine if an association was present between the search domains and subjects' satisfaction with the search process. The chi-square indicated no association between the distributions for the search domain categories and subjects' satisfaction with the search process (Chi-square=6.478, *df*=9, *p*=.691).

Subjects' Self-Assessment of Satisfaction with the Search Results

Table 21 displays results for subjects' self-assessment ratings for satisfaction with the search results that displayed as a result of the search process. Zero subjects were very dissatisfied with the search results. Only 15% of subjects indicated they were dissatisfied (2) with their search results. For the most part, 65% of the subjects were satisfied and very satisfied with the search results. However, 20% of subjects indicated they were neither satisfied nor dissatisfied with the search results.

Table 20. Counts for subjects' self assessment of satisfaction with search results

Search Domains	Satisfaction with Search Results					
	Very Dissatisfied 1	2	3	4	Very Satisfied 5	Total
Botany	0	3	3	3	6	15
Geometry	0	2	3	5	5	15
Literature	0	4	3	5	3	15
Psychology	0	0	3	4	8	15
Total	0	9	12	17	22	15
%	0	15%	20%	28%	37%	100%

A chi-square was calculated to examine whether there was an association between the distributions for the search domain categories and subjects' satisfaction with the search results obtained from the search process. Chi-square calculation indicated no association (Chi-square=6.900, df=9, p=.648).

Correlations of Interest, Knowledge, Satisfaction, Results, and Task Times

A Pearson Correlation indicated there was a positive correlation between domain knowledge and domain interest (Table 22). Subjects who expressed more interest in a domain, expressed more knowledge about that domain (r=.418, p=.01). There was also a strong positive correlation between subjects' satisfaction with the search process and their subsequent satisfaction with the search results (r=.760, with p=.01).

Interestingly, there was not a correlation between task times and domain interest, task times and search satisfaction, task times and knowledge. However, there was a negative correlation between task times and the satisfaction with search results (r=-.290, *p*= 05).

Table 21. Pearson Correlations for interest, knowledge, and satisfaction with search processes

		Interest	Knowledge	Sat-process	Sat-Results	task times
Interest	Pearson C.	1	.418**	.101	.124	-.067
	Sig. (2-tailed)		.001	.443	.344	.611
	N	60	60	60	60	60
Knowledge	Pearson C.	.418**	1	-.078	.060	-.018
	Sig. (2-tailed)	.001		.552	.649	.894
	N	60	60	60	60	60
Sat_process	Pearson C.	.101	-.078	1	.760**	-.159
	Sig. (2-tailed)	.443	.552		.000	.225
	N	60	60	60	60	60
Sat_results	Pearson C.	.124	.060	.760**	1	-.294*
	Sig. (2-tailed)	.344	.649	.000		.023
	N	60	60	60	60	60
task times	Pearson C.	-.067	-.018	-.159	-.294*	1
	Sig. (2-tailed)	.611	.894	.225	.023	
	N	60	60	60	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Reasons for Stopping Searches

After the subjects conducted each of the search tasks for each domain, they were asked to assess the extent to which each of the listed reasons affected their decision to end a search. Five reasons for stopping were listed based on categories explicitly stated from Brown et al. (2007). These are discussed in detail in the Methods section of this paper. To better understand the subjects' reasons for stopping an information search for each of the search domains, a description of the reason follows along with the data in Table 23.

Table 22. Means and SD of reasons per stopping per category (5-point scale where 1=none and 5=very much)

		Botany	Geometry	Literature	Psychology
A. I ended my search for documents because I satisfied all the items I needed from my mental list of items."	Mean S.D	4.33 .976	4.27 .884	4.40 .910	4.13 .990
B. I ended my search for documents because I retrieved a set of documents that were no longer changing.	Mean S.D	3.07 1.486	2.60 1.352	2.67 1.345	2.47 1.407
C. I ended my search for documents because I determined I was no longer learning anything new.	Mean S.D	3.07 1.387	2.60 1.242	2.80 1.424	2.27 1.163
D. I ended my search for documents because I skimmed the documents and determined what I had was "good enough.	Mean S.D	4.53 .743	4.33 .724	4.13 .990	4.27 .704
D. I ended my search for documents because I found the answer to a question that required a single answer.	Mean S.D	3.20 1.656	3.40 1.352	3.20 1.568	3.13 1.302

Correlation of Reasons for Stopping Searches

There were no correlations between reasons for stopping and task times; however, Table 24 shows a moderate positive correlation was calculated between reason B and reason C (r=.797, *p*=.01). The means for reasons B and C across the four domains were also very similar.

Table 23. Pearson Correlation for reason B and C

		Reason b	Reason c
Reason b	Pearson C. Sig. (2-tailed) N	1 60	.797** .001 60

The reason for this correlation might be that conceptually similar events (e.g. document not changing) were not clearly discernable enough for subjects to understand the differences between the two reasons. One item stated documents were not changing enough while the other item stated that documents were not changing enough for subjects to learn anything new. Clearly, this is a question about what subjects noticed about a set

of documents and if the subjects changed their behavior based on these observations. Thus, the idea was erroneously postulated that the subjects interpreted the two reasons as a different way of stating the same idea.

Search Tasks

The primary purpose of this study was to assess whether there was an association between users' level of domain knowledge and whether it influenced search stopping behavior which in this case was when people stopped an information search. Among the 15 subjects, a total of 60 search tasks were conducted within four different search domains. The mean task time among the 60 tasks was 3.9759 minutes with a range of .20 to 16.75 minutes. The SD was 3.145 minutes. However, the variance was 10.015 minutes, which was an unbiased estimate of the SD for the total 60 tasks without regard for category (Babbie, 2007). This value means that the variation from the mean was greater than the SD indicated for these tasks.

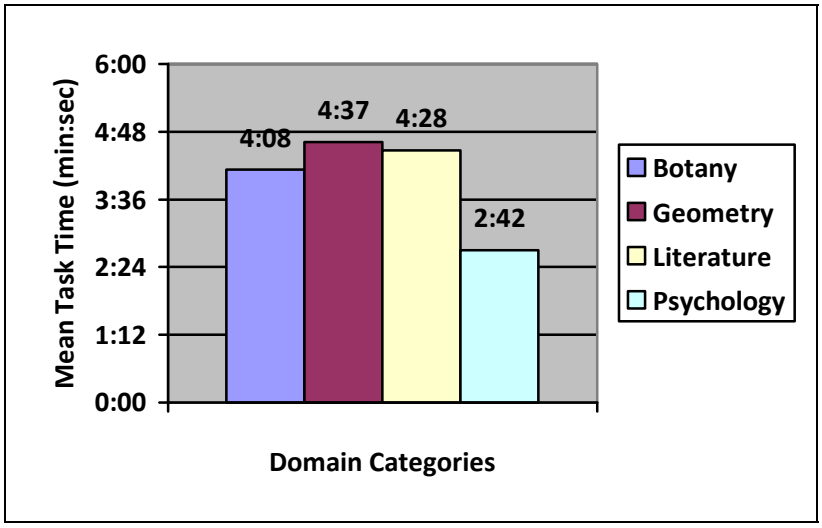
Thus the median task time was also calculated and was 3.36 minutes with ranges from .32 to 6.50. Task-times were shown to present a multi-modal population as shown in Table 25. For all 60 task times, each task time was unique with the exception of the modes in which each task time occurred twice.

Table 24. Measures of Central Tendency and SD for the time taken to complete search tasks in all domains (time in minutes-no seconds).

	N	Min.	Max.	Mode*	Median	Mean	SD	Variance
Task Times (in minutes)	60	.20	16.75	40, .68, .77, 3.60, 4.77, 6.85	3.3600	3.9759	3.16457	10.015
Valid N	60							
(*) means that there are multi-modes for this set of data. Each mode represents 3.3% of the data points in the data sets. All other data points represent 1.7% of the data set.								

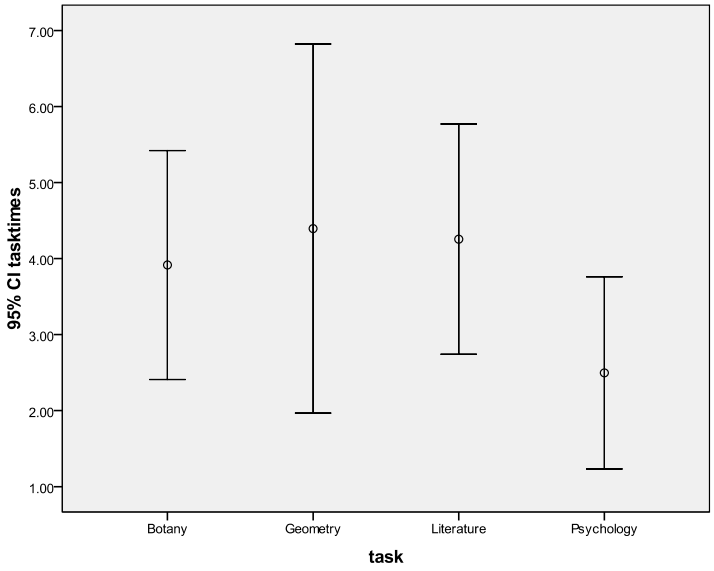
When the mean task times specific for each domain were calculated, Geometry, showed the longest mean search times (4:37 min:sec) while Psychology showed the shortest mean search times (2:42 min:sec). This information is shown in Figure 2.

Figure 2. Mean task times for domain-specific searches in minutes and seconds



The results indicated the mean shortest search time (2:42) was in Psychology. The longest task time was in Geometry (4:37). Figure 3 displays the mean task times per category and those data points within 95% of the means. Geometry displayed the greatest variance within the four search domains.

Figure 3. Mean task time plus 2 SD per category



The ANOVA compared the means of categorical groups that represented the independent variables (domains of Botany, Geometry, Literature, and Psychology) and compared how much each group differed from one another in terms of a dependent variable, in this case, task time (Table 26). The ANOVA showed that the results were not significant.

Table 25. Between and within group ANOVA results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.024	3	11.341	1.154	.335
Within Groups	550.140	56	9.824		
Total	584.164	59			

Summary of Responses to Interview Questions

Because we do not really know the motivation for people to stop an information search, it seemed to be reasonable to collect qualitative data to explore users' thinking processes for making such decisions. This study resulted in the collection of qualitative data as results of post-test interviews with the subjects.

Pre-results: questions about the process of investigating the answer to a task question

1. *How did you determine what info to search for to complete the task?*

Most of the subjects indicated they chose queries terms based on what seemed to be most important in the search tasks presented. What seemed to be most important to the subjects was that they obtain a general review or general knowledge about the terms suggested in the scenarios. Searches were conducted mostly by reading the scenario and then choosing the key terms to use as query terms in Google. From the sites listed by Google, subjects identified those websites that would contain general information. Subjects also indicated they looked for biographies. If the query terms did not retrieve relevant documents, then they would add more search terms to the initial term.

2. *Where did you look for information?*

All subjects (100%) indicated they searched Google and then chose Wikipedia form the list of retrieved results. One subject indicated Wikipedia was biased but it was still usable for general information. Another subject stated Wikipedia provided a good overview. And another subject stated he never exclusively relied on Wikipedia. Subjects indicated they selected other sites from the list such as those that had an .edu extension, Britannica, ask.com or reputable sources such as those associated with Stanford University.

3. *What criteria did you use to evaluate the search results?*

One subject indicated he trusted Wikipedia completely, while another stated she chose to trust Wikipedia although she knew it was not the safest. Others indicated they scanned the headings for keywords and choose selections based on what seemed true. Many stated that that they looked for websites they felt were credible such as those

ending with .edu, Britannica, scientific databases. One subjects indicated he choose by what was most accessible and easily listed info he could process based on its organization.

4. *Did you know the answer to a question without searching for the answer?*

Most subjects indicated they were familiar with Carl Jung. A few subjects indicated they were familiar with Pythagoras and the Magnolia. None of the subjects (100%) were familiar with *The Sand Pebbles*.

5. *If you were familiar with the topic, where/how did you search for information?*

Most of the subjects indicated they would still use the same search method and use Google and Wikipedia as sources. A few subjects indicated they would place bibliography next to the name of the person in the search field, or pair other search terms to make the search more specific.

Post results: questions about the process of deciding upon the answer that will answer the task question

1. *What criteria did you use to decide the answer was the one you wanted?*

Most subjects indicated they would choose the answer that seemed most relevant and that would answer the question. Other subjects indicated they were more casual in their responses and indicated if the answer seemed plausible, they would use it. A few subjects indicated they would look for keywords that were the same as those in the search tasks. And lastly, a few subjects indicated they would check two to three citations to confirm that the answer was indeed correct.

2. *Were you satisfied with the search results?*

All subjects were satisfied with their search results with a few exceptions. One subject was frustrated because Google has a lot of "junk" and all search paths lead to Wikipedia. One subject indicated he felt he was not as good a searcher as he thought he was because he was not finding the results he wanted. Another indicated for the most part he was satisfied but would not use Wikipedia if it was a research paper. The most troublesome issue was to find information for *The Sand Pebbles* that was book-related instead of the movie.

3. *How did you determine the answer was good enough?*

Most subjects indicated they felt the answer was good enough if it answered a question that was basic information that someone would want to know, and was relevant to the topic. Other subjects commented that if they felt there was enough information there and they understood what they were reading and had no more questions. A few subjects indicated they trusted the web site (one subject indicated he trusted Wikipedia), or if the answer could be corroborated by another source and it made sense within the scenario given. The implication is that if it is explained well, then the information might be more credible and thus it was usable information.

4. *What did you learn about the topic?*

For the most part, all subjects (100%) indicated they learned new information from completing these search tasks. About half of the subjects described all of the information they learned and were somewhat enthused about the new information as they described it. Other subjects indicated the keywords in the domains as having learned something about that topic, such as McKenna or the book or Carl Jung. A few simply

stated that they learned basic information or one stated I learned the facts that I wrote down during the search task or yes, I learned information about all of the domains.

Discussion and Conclusions

The literature review in this paper provided a discussion around some of the influences that researchers proposed comprise part of the information search processes and contributed to people ending information searches. Users' complex behaviors were influenced by many internal and external variables. This complexity was reflected in those behaviors associated with search stopping behavior. Search stopping behavior had become associated with those heuristics that people knowingly or unknowingly use to end information searches.

This literature review examined the types of tacit thought processes that influenced people throughout the search process resulting in their decisions to end information search tasks. For example, the satiation rule stated that people ended searches once they became satisfied with the search results while the disgust rule stated that people ended searches once they became disgusted with the search. Researchers have also investigated the idea that stopping behavior had a predicative quality that had not yet been empirically investigated and measured. Brown et al. (2004, 2007) suggested levels of complexity and levels of task experience were inversely proportional when they influenced when people determined to end searches, thus lending a predictive nature to stopping behavior. Lastly, researchers theorized about how people decide they have enough information to end searches by conducting cost-benefit analyses and making conscious decisions to satisfice.

Empirical research suggested ways in which domain knowledge might influence search behavior which supports thinking about search stopping behaviors. Wildemuth (2009) conducted an empirical study to investigate how domain knowledge influenced the search process. One idea from this study was that those users with greater experience in a knowledge domain might approach the search process differently than those who were novices to the domain so domain knowledge influenced the search processes users employed. However, empirical research was lacking that serves to address if and how users' level of knowledge influenced their thinking processes to make decisions to end an information search.

Assumptions about Subjects

Subjects enrolled in this study indicated they spent about 1-5 to 16-20 hours per week in which they conducted three types of searches with more time spent on exploratory search tasks. Subjects rated their computer experience, specifically their web search experience as greater than average but less than expert level. Web search was the activity in this study in which subjects were requested to engage. The mean self-efficacy for all 15 subjects' responses was 7.27. On the whole, subjects assessed themselves as more than reasonably confident to near expert in their abilities to perform different search tasks on the Internet. This suggested that the researchers might review the data from the study in the context of a sample population who was considered skilled with computer search activities and confident in their abilities to conduct search activities on the Web. It was in this context that the following results were discussed.

Discussion of the Study Results

Because stopping behavior was a small but significant part of the search process, the lack of empirical studies in search stopping behavior in the research literature fueled the thinking for the design of this study. Additionally, as was found in this study, search stopping behavior was complex and not reliant on any one variable. What is the relationship between the subjects' level of domain knowledge and their search stopping behavior represented by task times?

The ANOVA (F ratio =1.154, p =.335) was calculated and indicated the between group differences were sensitive to the intervention effects of the subjects' levels of domain knowledge (F value was greater than 1). This might mean that the intervention of domain knowledge technically influenced search task times. However, the p value indicated the differences between the means were not significant; therefore, levels of domain knowledge might influence search stopping behavior, but if so, it was not a statistically significant influence.

This means that the differences due to domain categories were not significant in this study. Subjects' knowledge about domains had little if any relation to the times taken to complete search tasks. Geometry had the longest search time (as shown in Figure 1.). Only 20% of subjects indicated they had an average or greater interest. Many subjects, 80%, indicated an average or greater than average knowledge level about Geometry. However, subjects indicated they were least satisfied with their search results for Geometry. To summarize, Geometry had long search times, high knowledge levels, low interest levels, and low satisfaction with the search results. Thus the data for Geometry

does not support the notion that the subjects' level of domain knowledge influences the decision to end an information search.

In contrast, Psychology had the shortest search time. Subjects indicated they had the greatest satisfaction with search results (as shown in Figure 1.). Interestingly, 73% of subjects indicated average and greater than average knowledge about Psychology. To summarize, Psychology had short search times, high knowledge levels, high interest levels, and high satisfaction with the search results. However, the high knowledge level does not account for the shorter search times. This data highlighted other relationships and influences that might shed light on those influences people used to end information searches.

Positive Correlations between Domain Knowledge and Interest Levels

Interestingly, the results obtained from this study indicate there was a moderate association between subjects' level of domain knowledge and their level of interest in a domain. Subjects who expressed interest in a domain and knowledge about a domain were positively correlated (r=.418, p<0.01). This might mean that subjects were interested in domains for which they were knowledgeable or that they were knowledgeable about those domains for which they were interested.

This interpretation might make sense if one expected that students enrolled in courses for which they were interested and avoided those in which they were uninterested. Hence, if they enrolled in courses of interest, then their level of knowledge increased. The converse might also be true that courses in which students avoided due to lack of interest resulting in less knowledge about those domains.

Knowledge or interest in domains might not independently influence stopping behavior but these finding suggested that perhaps a combination of the two variables might be influential. Knowledge and interest might be tandem variables that influenced how subjects searched for information. Together they might influence satisfaction with the search process and the retrieved search results that ended in subjects ending information searches. This would also be an area for future study.

Positive Correlations between Satisfaction with the Search Processes and Search Results

These results suggest that as subjects retrieve results that satisfy their type of search task, such as genera, specific, or exploratory, subjects are satisfied with the search process. This means that not only are the results important but the process by which subjects locate appropriate search results are important.

More interestingly, the results from this study indicated a strong correlation between subjects' satisfaction with the search process and with the search results obtained from the search process (r=.760, p=.01). This correlation suggested that subjects identified satisfaction with search results as indicative of satisfaction with the search process. As subjects searched for information to locate answers so to complete the search tasks, they became either satisfied or dissatisfied. The more satisfaction they experienced with the search results, the more likely they were satisfied with their search process that retrieved those results.

Conversely, this might also mean that subjects who were satisfied with the search process as it occurred were more likely satisfied with the search results; knowing the retrieved results would present information for them to complete their search task. This

thinking is supported by the demographic data interpreted and concluded with the assumptions discussed earlier: The subjects were considered skilled with computer search activities and confident in their abilities to conduct search activities on the Web.

During the exit interview, subjects were asked about the search process and how they attempted to achieve successful searches that resulted in satisfaction with the search process and retrieved results. Most of the subjects indicated they chose queries terms based on what seemed most important in the search tasks presented. What seemed most important to the subjects was that they obtained a general review or general knowledge about the terms suggested in the scenarios. Subjects conducted searches mostly by reading the scenarios and then extracting the key terms to use as query terms in Google. From the sites listed by Google, subjects identified those websites that contained general information. Subjects also indicated they looked for biographies. If the query terms did not retrieve relevant documents, then they added more search terms to the initial term.

All subjects (100%) indicated they searched Google and then chose Wikipedia from the list of retrieved results. All subjects responded that they used Google as their search engine from which to conduct their searches. From the Google results page, subjects stated they used Wikipedia as the main source of information or as one of one or more information sources. Even if subjects indicated they knew the answer to a question or were familiar with the question domain, they choose to search Google and Wikipedia. One subject indicated Wikipedia was biased but it was still usable for general information and another subject stated Wikipedia provided a good overview.

However, in spite of subjects have a range of views about Wikipedia as an information source that supplied information for them to complete their search tasks, one

subject stated he never exclusively relied on Wikipedia. Subjects indicated they selected other sites from the retrieved list of sites they felt were credible, such as those identified with an .edu extension, Britannica, scientific databases, ask.com, or as one subjects stated, reputable sources such as those associated with Stanford University. Yet, another subject indicated he trusted Wikipedia completely, while another stated she chose to trust Wikipedia although she knew it was not the safest. Others indicated they scanned the headings for keywords and choose selections based on what seemed true. One subject indicated he choose information by what was most accessible and easily listed based on credibility he felt he could interpret based on its organization.

These responses also indicate the rise in credibility in collaborative social networking information as a source for general and exploratory information searching. In fact, in the exit interviews, Wikipedia was linked in interviews with encyclopedias, bibliographic sources, or other educational sources of information that were reputable and that should be used as primary information sources (since they reported they cannot cite Wikipedia in a paper). Once subject stated she "trusted Wikipedia" without a need to consult another source. Another subject indicated he would use Wikipedia along with a second source to corroborate the answer before accepting the answer to a search query from Wikipedia. One subject indicated if she were looking for information about a person, she would bootstrap the term *bibliography* next to the person's name in the search box. However, the first choice was still Wikipedia.

Once subjects retrieved results, they evaluated the results to obtain the answer to the search task. How did subjects evaluate their satisfaction with identifying answer in the search results? Most subjects indicated they would choose the answer that seemed

most relevant and that would answer the question. Other subjects indicated they were more casual in their responses and indicated if the answer seemed plausible, they would use it. A few subjects indicated they would look for keywords that were the same as those in the search tasks. And lastly, a few subjects indicated they would check two to three citations to confirm that the answer was indeed correct.

All subjects were satisfied with their search results with a few exceptions. One subject was frustrated because Google has a lot of "junk" and all search paths lead to Wikipedia. Another indicated for the most part he was satisfied but would not use Wikipedia if it was a research paper. One subject indicated he felt he was not as good a searcher as he thought he was because he was not finding the results he wanted. The most troublesome issue was to find information for *The Sand Pebbles* that was book-related instead of the movie.

Clearly, one can see that subjects are continually performing cost-benefit analyses about how to create a successful search that presents results that leads them to successful responses to the search tasks.

Negative Correlations between Satisfaction with Search Results and Search Task Times

There was a negative correlation between task times and the resultant search results (r=-.294, p= .05). This suggests that the subjects' satisfaction with the search results increased as the length of search task times decreased. This negative correlation between satisfaction with search results and task times lends support to the satiation and disgust rules as cognitive stopping rules subjects' employed to end information searches. As the subjects became increasingly dissatisfied with the search results, they were

motivated to keep searching thereby increasing the task time. Conversely, the more satisfied subjects were with the search results, the shorter the task times. This sentiment indeed was expressed in the exit interview regarding the literature search task.

This data might also indicate that subjects were most satisfied when their searches revealed the answers to their search query in the most efficient manner. As an example, subjects indicated in the exit interview that the literature search was the most challenging search because they were unable to easily locate any web sites about the book *The Sand Pebbles*. There was a large collection of web sites devoted to the movie made from the book along with those sites about the historical event. However, subjects stated it required extended effort to retrieve information about the book and the author. Interestingly, during the exit interview, subjects indicated that this was the domain about which they learned the most. Many of subjects were excited to learn that the author was a student who attended the same university and received straight As.

Subjects indicated they were satisfied with the search processes about the domains in the following order (Botany, Literature, Psychology, and Geometry); however, most subjects indicated they were equally satisfied with the search results in from all the domains in the order of (Psychology, Geometry, Botany, and Literature). Literature was listed last possibly because many subjects stated in the exit interviews they had problems with finding information about the book whereas it was easy to find information about the movie and fan sites and historic information about the premise for the book.

When asked during the Exit Interview about if they were satisfied with the search results, subjects indicated they were satisfied with their search results with a few

exceptions. One subject was frustrated because Google has a lot of "junk" and all search paths lead to Wikipedia. One subject indicated he felt he was not as good a searcher as he thought he was because he was not finding the results he wanted. Another indicated for the most part he was satisfied but would not use Wikipedia if it was a research paper. The most troublesome issue was to find information for *The Sand Pebbles* that was book-related instead of the movie.

When asked during the Exit Interview how they determined their answers were good enough, most subjects indicated they felt the answer was good enough if it answered the question with basic information that they thought someone would want to know, and that was relevant to the topic. Other subjects commented that if they felt there was enough information, they understood what they were reading, and had no more questions. A few subjects indicated they trusted the web site, such as one subject indicated he trusted Wikipedia thus they would implicitly trust the answers to be correct, or if the answer was corroborated by another source and it made sense within the given scenario. The implication was that if it was explained well, then the information was more credible and thus it was usable information.

Perhaps this is one of the contexts in which subjects' *satisfice* information. Subjects who were increasingly dissatisfied with the search results and thus took longer time to complete a search may be prime candidates for the satisficing behavior. It appears based on the exit interviews that most people tried to find the result that answered the questions.

No significant correlation when compare category means (F=1.154, $\boldsymbol{p}$ =.335)

Positive Correlations Between Reason B and C for Ending Information Searches

Correlations were strongly positive for reasons B and C when subjects decided to end searches (r=.697, *p*=.01). This correlation is likely due to study limitations and issues of validity. The reason for a correlation between reasons B and C might be that they both represented conceptually similar events and lacked a clearly identifiable explanation that was inadequately conveyed to the subjects.

Reason B implied the pool of retrieved documents was not changing enough to make it worthwhile for the subjects to continue the information search. Reason B states "I retrieved a set of documents that were no longer changing" and encourages the subjects to fill in the gaps about *why* the documents were not changing. Additionally, in relation to reason B, reason C implied that the pool of documents were not changing enough for subjects to learn anything new to make the benefits of continuing the information search worth the cost of the extended effort. Reason C stated that subjects stopped an information search because "…I determined I was no longer learning anything new." Reason C might be considered one of the implied reasons that subjects used to fill in the gaps about why the documents were no longer changing in reason B.

Reasons C also did not address why the subjects did not learn anything new. Are no new documents being added to the document pool? Are documents that have already been reviewed not being removed from the pool of retrieved documents? Do subjects no longer wish to review documents to learn any more information about the search task? Are subjects tired of the search tasks?

All subjects indicated in the exit interview that they learned new information so perhaps subjects only wanted to learn enough to complete the search tasks and thus consciously decided to satisfice (Simon, 1955). This would support the notion presented in the literature review that people consciously make cost-benefit analysis about what exactly constitutes good enough information. This decision might be based on context (Prabha et al., 2007) in which, in this case, the subjects decided they reviewed a sufficient number of web sites to retrieve good enough answers that allowed them to complete the search task for an experimental search. One subject stated during the exit interview that if this search task was for a paper, he "would not use Wikipedia as an information source." This indicated that subjects bring awareness to information searches about context and purpose. As they search, they consistently evaluate and re-evaluate as they make cost-benefit analyses about what exactly constitutes good enough information for a particular role they play in a particular context.

Thus, the ideas represented in reason B and C was inadequately postulated such that the subjects understandably interpreted the two reasons as different way of stating similar ideas.

Study Implications

Researchers are taking a greater interest in the area of search stopping behavior. This research hopes to lend some research data to the topic as a whole. The results of this study indicate that the current sample population for this study was experienced and confident in the search behavior. The results indicated that search satisfaction and search results are uniquely tied in their satisfaction experience. The results indicate that

knowledge and interest are also related. This study indicates that these relationships may influence search stopping behavior by providing some motivations for stopping searches.

Limitations of Study

One limitation of small studies was that it was difficult to calculate any statistics other than descriptive statistics, and even those might provide questionable results. Another limitation of the study population is the use of a convenience sample because these subjects are not a representative sample of the population at large. The results obtained from such a study population are not necessarily generalizable to the entire population.

However, despite both these disadvantages, the combination of methods used in this study made the small number of subjects less objectionable and more acceptable and thus might still offer valuable information about the study topic.

The validity of the instruments used might be a limitation of this study. The instruments were tested with two other graduate students. It might have been wiser to test the instruments with target subjects. This was particularly true when it came to reasons for ending searches, specifically the headings used in the instruments and the wording of the reasons, specifically reasons b and c. These two reasons might not have been distinguishable enough from each other.

Another limitation was the way that the time measurements were collected. The assumption was that the search tasks were conducted in a linear process: subjects entered a task number in the search box, then read the search task, searched the Web for answers (results), and then recorded the answers to their questions. However, it was unclear if this was the actual order of events. Subjects might have read the search task and recorded

the answers to the questions throughout the search process. If this was the case, then the search time equaled the time to read the search tasks and perform the search task while concurrently recording answers to the search tasks.

One more limitation may have been the quality of the scale used to measure domain knowledge. One subjects indicated they were an expert in Psychology, which in this scale was a five. This response demonstrates the relativity of the scale. A Ph.D. Psychologist would score a five on this scale. Therefore, the current scale used might not adequately reflect knowledge differences.

The search tasks might benefit from further validity and reliability testing. Also, the search tests were presented in scenario form and designed so that subjects would search at a minimum of two possible web sites for information to answer the questions in the search tasks. Wikipedia allowed subjects, with the exception of the literature search, to obtain most answers from their site without viewing other sites. The search tasks were also designed to take into account the reasons subjects may end an information search as described by Brown et al. (2004, 2007). This search task design could further benefit from further validity testing and design to address these issues clearly.

Potential Future Research

The data from this study suggests that subjects' decisions to end information searches were the results of multi-faceted, decision-making processes that incorporate multiple variables. Further analysis and evaluation of the transaction log data to review the web sites examined by the subjects and the queries they used to search web sites would be interesting. This might provide valuable information about the subjects' process of searching for information as complete their search tasks, such as reveal if they stayed

on topic, the number and types of web sites they visited and then comparisons against some of the variables in this study.

It would be interesting to conduct this study with those who were considered an expert population or other population groups to examine if the results produced were comparable to those results from the data and the interviews.

Most importantly, it would be interesting to conduct further studies about the variables and relationships presented in this paper to determine if there were a difference in search satisfaction among expert and non-experts alike. Lastly, conducting a study in which a subjects' level of knowledge was obtained by an analytical test that compared their assessment of expertise with their own test results. And then enrolling a population of experts and non-expertise alike might be an interesting in a similar future study.

Conclusion

While the process of search behavior has been extensively researched, the process of stopping behavior has produced limited research results. The topic of stopping behavior was investigated using a convenience sample of undergraduate and graduate students at the local university. This study investigated whether users' level of domain knowledge influences their decisions to stop information searches. The rise in Internet, Web-based and electronic library search has made this question important for understanding users' behavior and for developing these resources. A series of questionnaires and interviews were collected to determine how domain knowledge influences search stopping time and interviews to determine reasons for stopping. The results of the study indicated that there was an association between knowledge level and stopping behavior. The results also indicated that there was an association between

satisfaction with the search process and the retrieved search results. However, the results also indicated there was not an association between domain knowledge and search stopping behaviors.

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